Concept Evaluation and Selection

Chapter 8

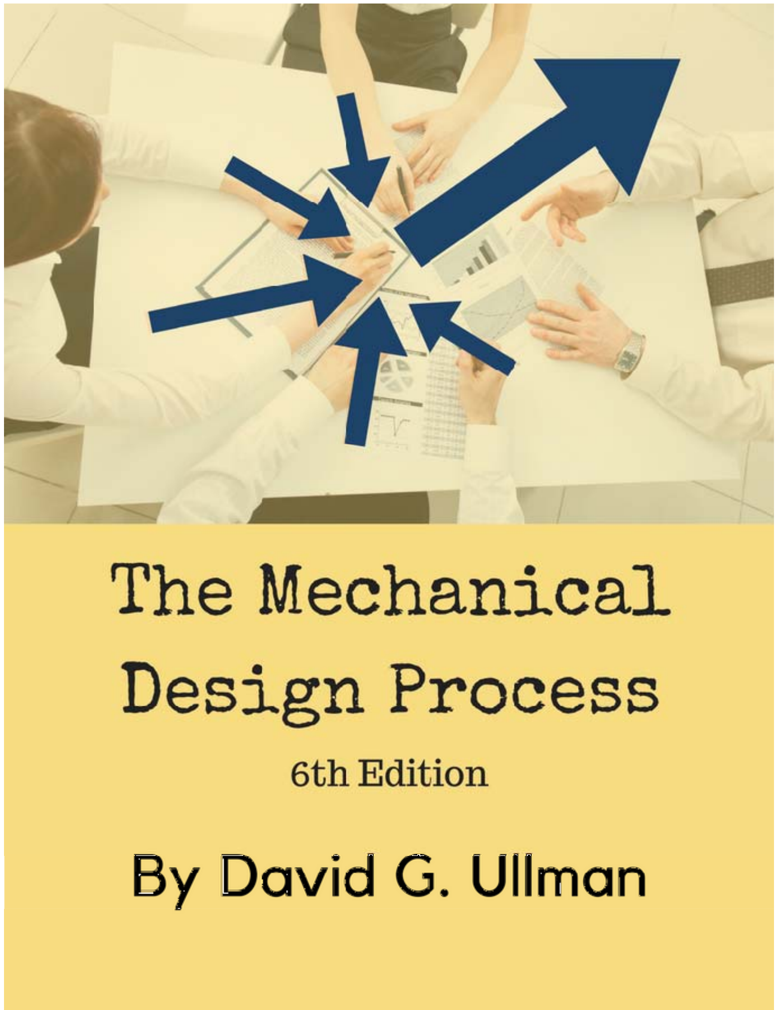
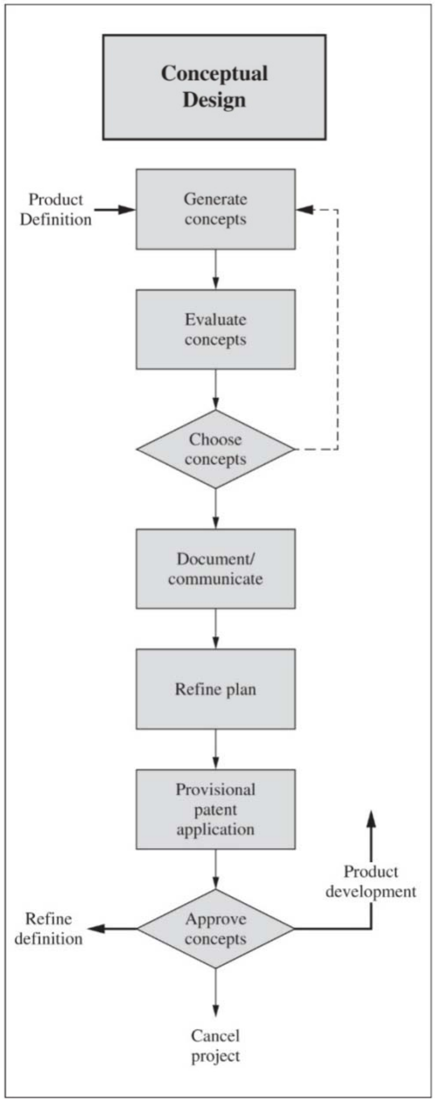


Figure 8.1



Conceptual Design
Product Definition
Generate concepts
Evaluate concepts
Choose concepts
Document/ communicate
Refine plan
Provisional patent application
Product development
Refine definition
Approve concepts
Cancel project

Figure 8.2

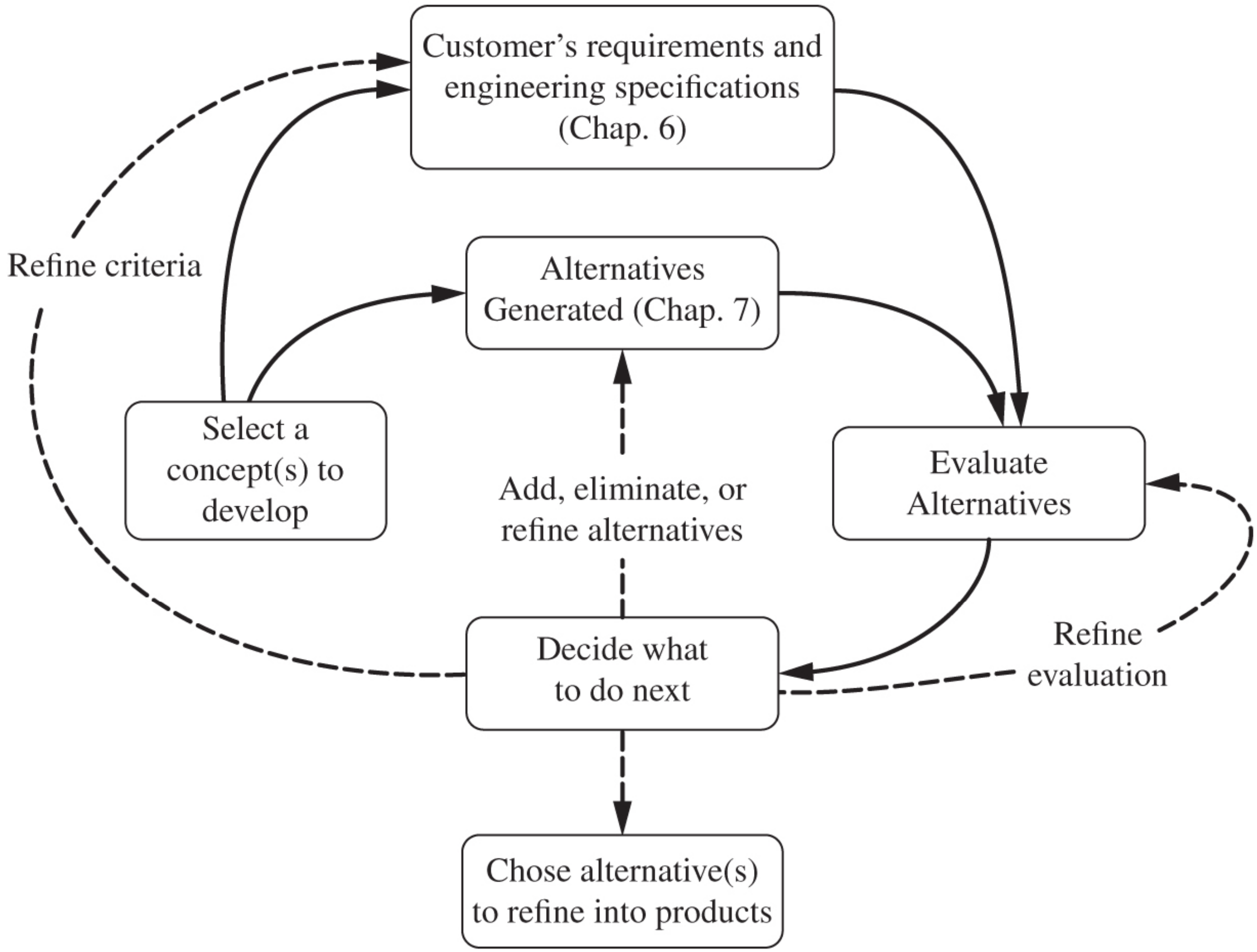

Customer's requirements and engineering specifications (Chap. 6)
Refine criteria
Alternatives Generated (Chap. 7)
Select a concept(s) to develop
Evaluate Alternatives
Add, eliminate, or refine alternatives
Decide what to do next
Refine evaluation
Chose alternative(s) to refine into products

Figure 8.3

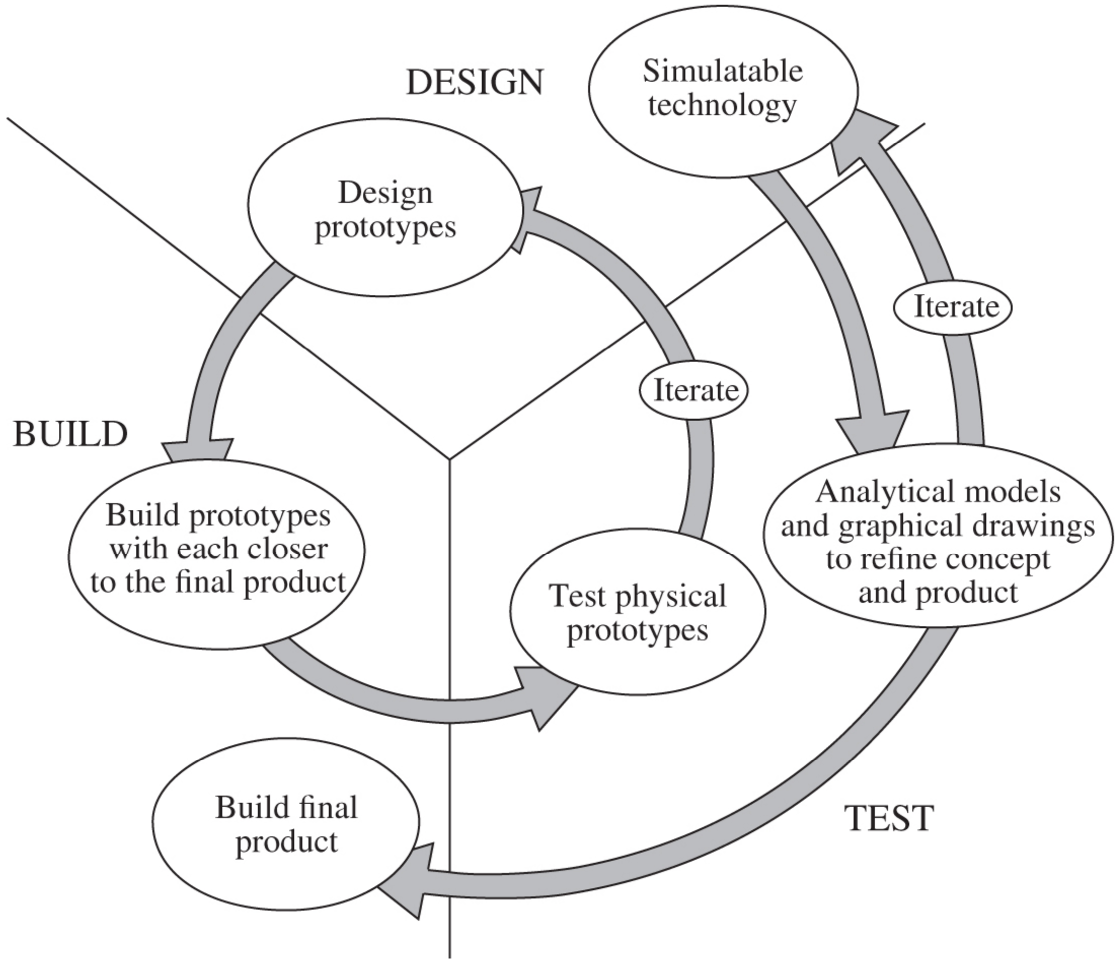

DESIGN
Simulatable technology
Design prototypes
Iterate
Iterate
BUILD
Build prototypes with each closer to the final product
Test physical prototypes
Analytical models and graphical drawings to refine concept and product
Build final product
TEST

Figure 8.4

David Ullman

Figure 8.5

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Table 8.1 A time line for technology readiness

Technology	Development time, years
Powered human flight	403 (1500–1903)
Photographic cameras	112 (1727–1839)
Radio	35 (1867–1902)
Television	12 (1922–1934)
Radar	15 (1925–1940)
Xerography	17 (1938–1955)
Atomic bomb	6 (1939–1945)
Transistor	5 (1948–1953)
High-temperature superconductor	? (1987–)

Technology Readiness Assessment

Design Organization: | **Date:**

Technology being evaluated:

Critical parameters that control function:

Parameter	Functions Controlled	Operating Latitude	Sensitivity	Failure Modes

Does hardware/software exist that demonstrates the above?

(Attach photos or drawings)

Describe the processes used to manufacture the technology:

Is

Team member:	Prepared by:
Team member:	Checked by:
Team member:	Approved by:
Team member:	

The Mechanical Design Process Designed by Professor David G.Ullman

 Form # 12.0

Table 8.2 Definition of Technology Readiness Levels

TRL 1 Basic principles observed and reported: Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures. Descriptive tools are mathematical formulations or algorithms.

TRL 2 Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.

TRL 3 Analytical and experimental critical function and/or characteristic proof-of-concept: Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brassboard implementations that are exercised with representative data.

TRL 4 Component/subsystem validation in laboratory environment: Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.

TRL 5 System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7 System prototyping demonstration in an operational environment (ground or space): System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.

TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space): End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

TRL 9 Actual system "mission proven" through successful mission operations (ground or space): Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operational experience. Sustaining engineering support in place.

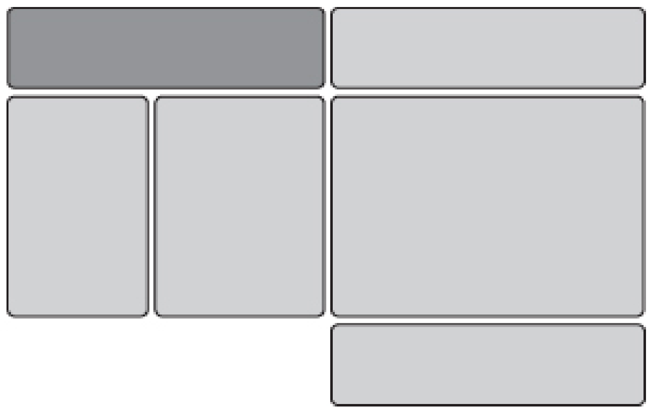
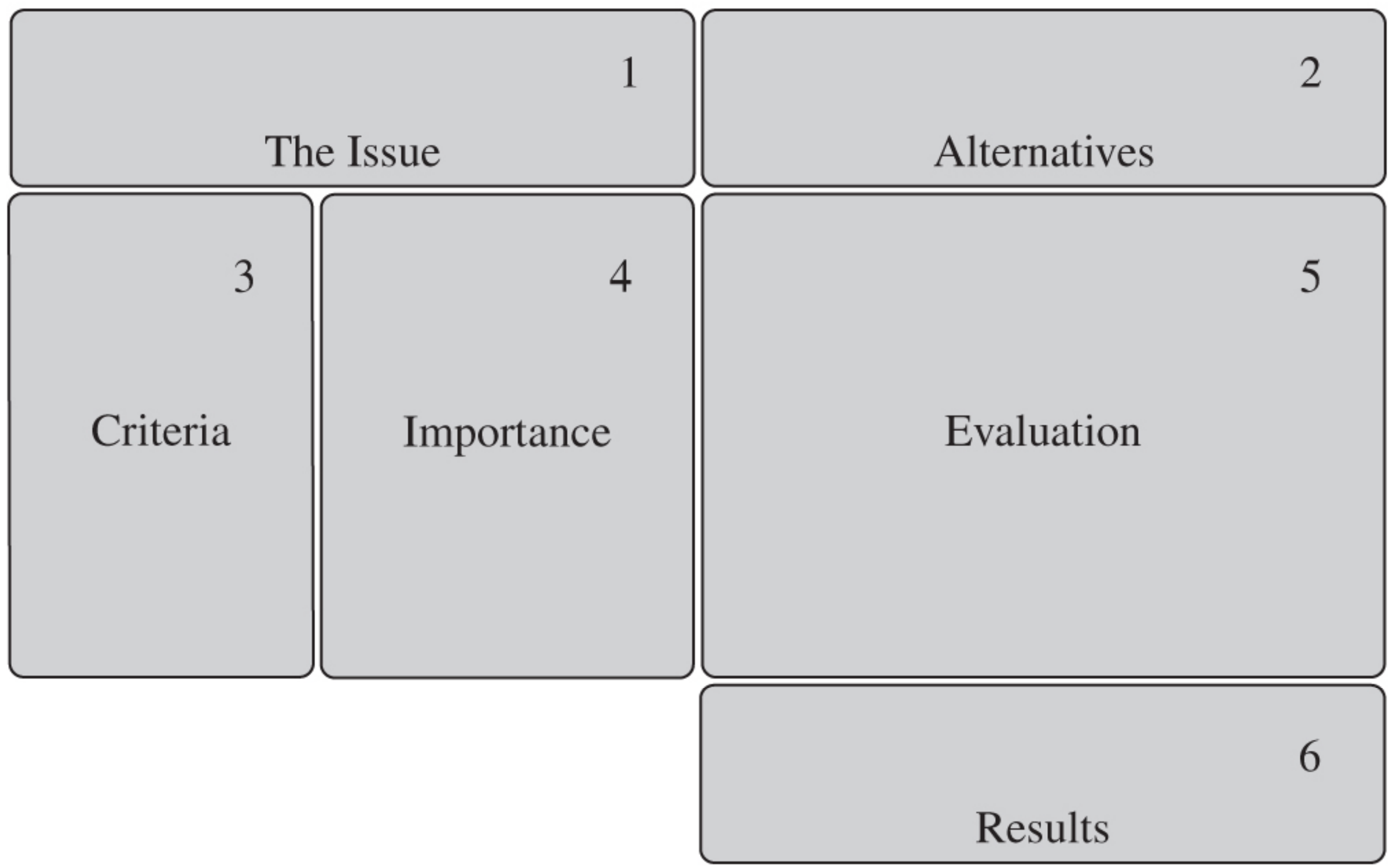
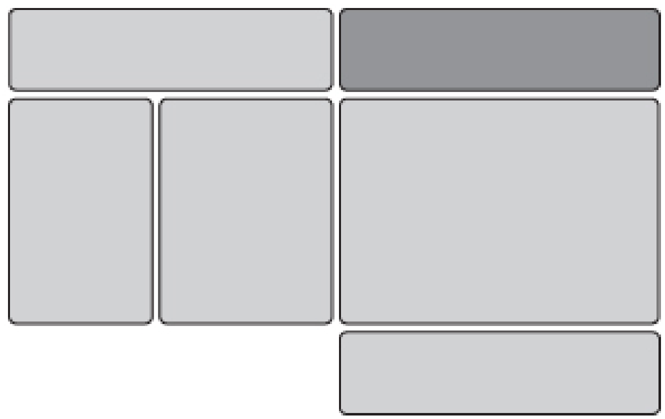
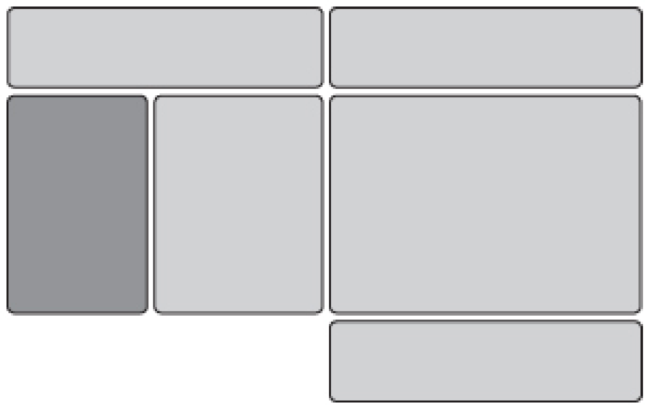
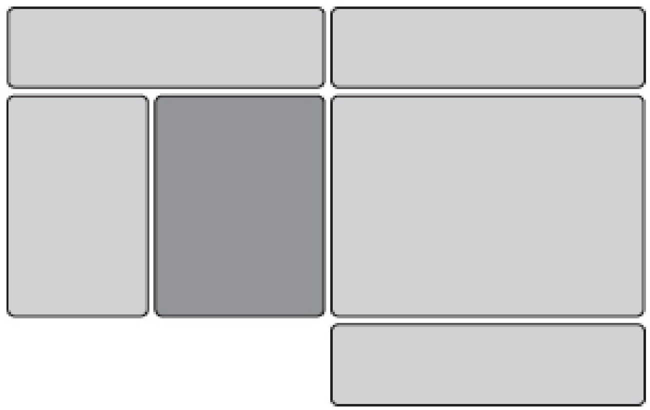


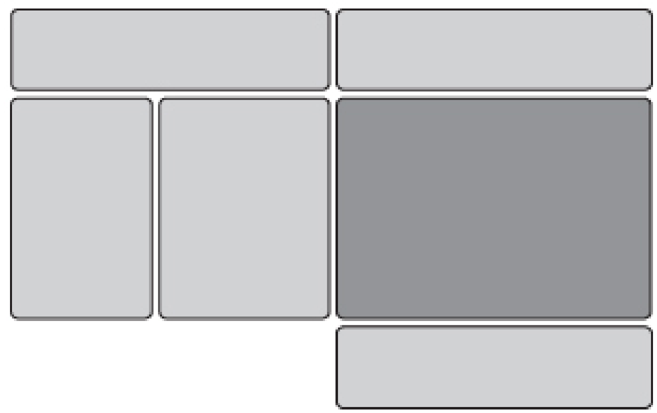
Figure 8.7


1
The Issue
2
Alternatives
3
Criteria
4
Importance
5
Evaluation
6
Results









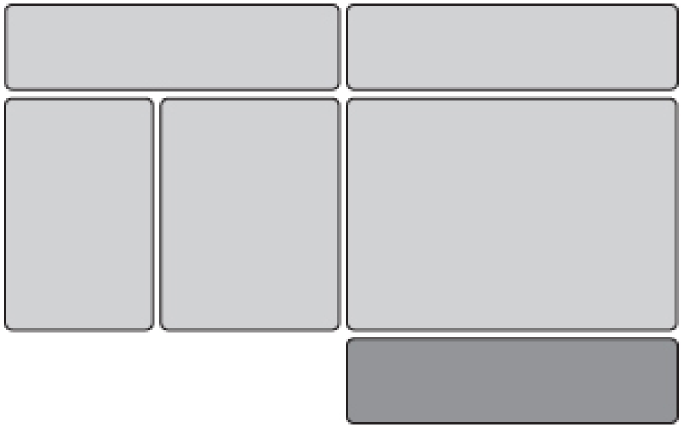


Figure 8.8

Cantilevered beam

Hub switchbacks

Spiral flexures

David Ullman

Figure 8.9

Issue: Choose a MER wheel configuration		Baseline	Cantilevered Beam	Hub Switchbacks	Spiral Flexures	Multipiece
Mass efficiency	35	Datum	0	0	1	?
Manufacturability	10		0	−1	−1	?
Available internal wheel volume	20		1	1	1	?
Stiffness	35		1	1	1	?
	Total		2	1	2	?
	Weighted total		55	45	80	?

Figure 8.10

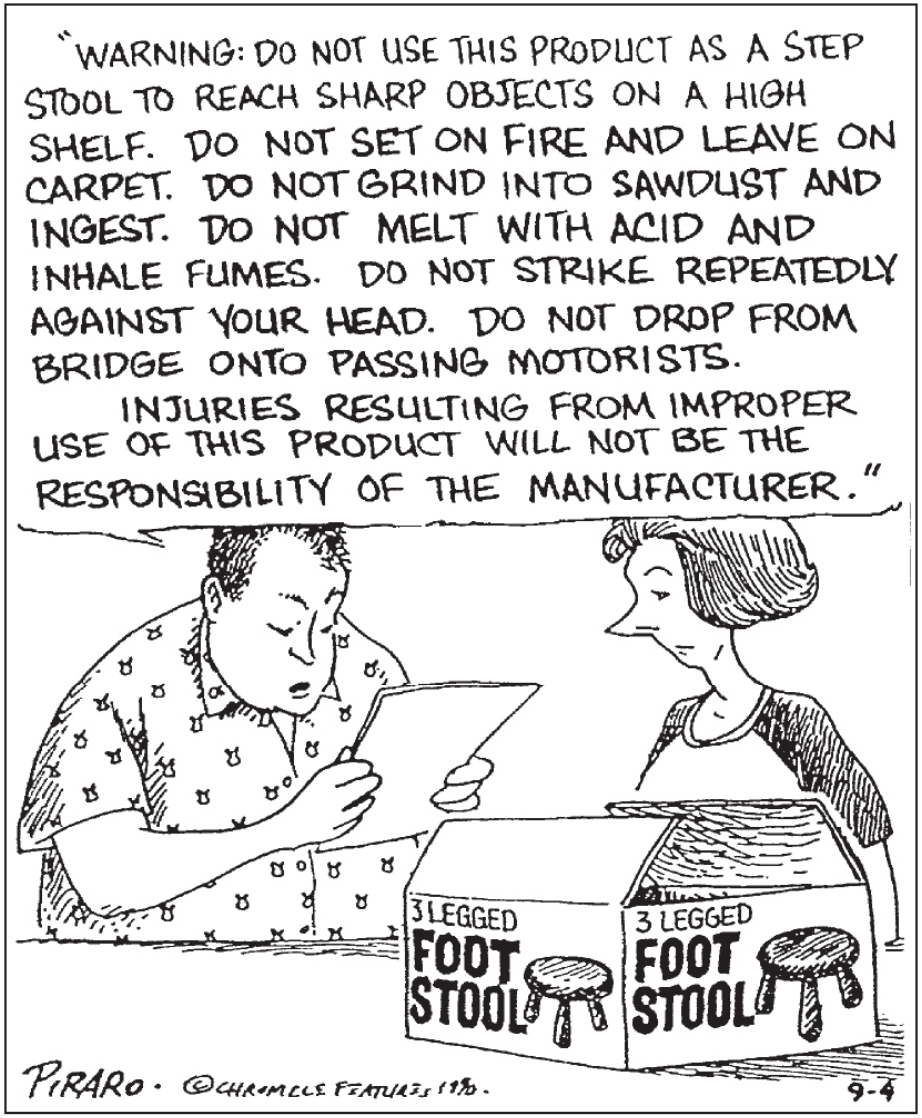

"WARNING: DO NOT USE THIS PRODUCT AS A STEP STOOL TO REACH SHARP OBJECTS ON A HIGH SHELF. DO NOT SET ON FIRE AND LEAVE ON CARPET. DO NOT GRIND INTO SAWDUST AND INGEST. DO NOT MELT WITH ACID AND INHALE FUMES. DO NOT STRIKE REPEATEDLY AGAINST YOUR HEAD. DO NOT DROP FROM BRIDGE ONTO PASSING MOTORISTS.
INJURIES RESULTING FROM IMPROPER USE OF THIS PRODUCT WILL NOT BE THE RESPONSIBILITY OF THE MANUFACTURER."
3 LEGGED FOOT STOOL
3 LEGGED FOOT STOOL
PIRARO
9-4

Table 8.3 The mishap probabilities

Description	Level	Individual item	Inventory
Frequent	A	Likely to occur frequently (probability of occurrence > 10%)	Continuously experienced
Probable	B	Will occur several times in life of an item (probability of occurrence = 1ñ10%)	Will occur frequently
Occasional	C	Likely to occur sometime in life of an item (probability of occurrence = 0.1–1%)	Will occur several times
Remote	D	Unlikely, but possible to occur in life of an item (probability of occurrence = 0.001ñ0.1%)	Unlikely, but can reasonably be expected to occur
Improbable	E	So unlikely that it can be assumed that occurrence may not be experienced (probability of occurrence < 0.0001%)	Unlikely to occur, but possible

Table 8.4 The mishap severity categories

Description	Category	Mishap definition
Catastrophic	I	Death, system loss, or severe environmental damage
Critical	II	Severe injury, occupational illness, major system damage, or reversible environmental damage
Marginal	III	Minor injury, minor occupational illness, minor system damage, or environmental damage
Negligible	IV	Less than minor injury, occupational illness, system damage, or environmental damage

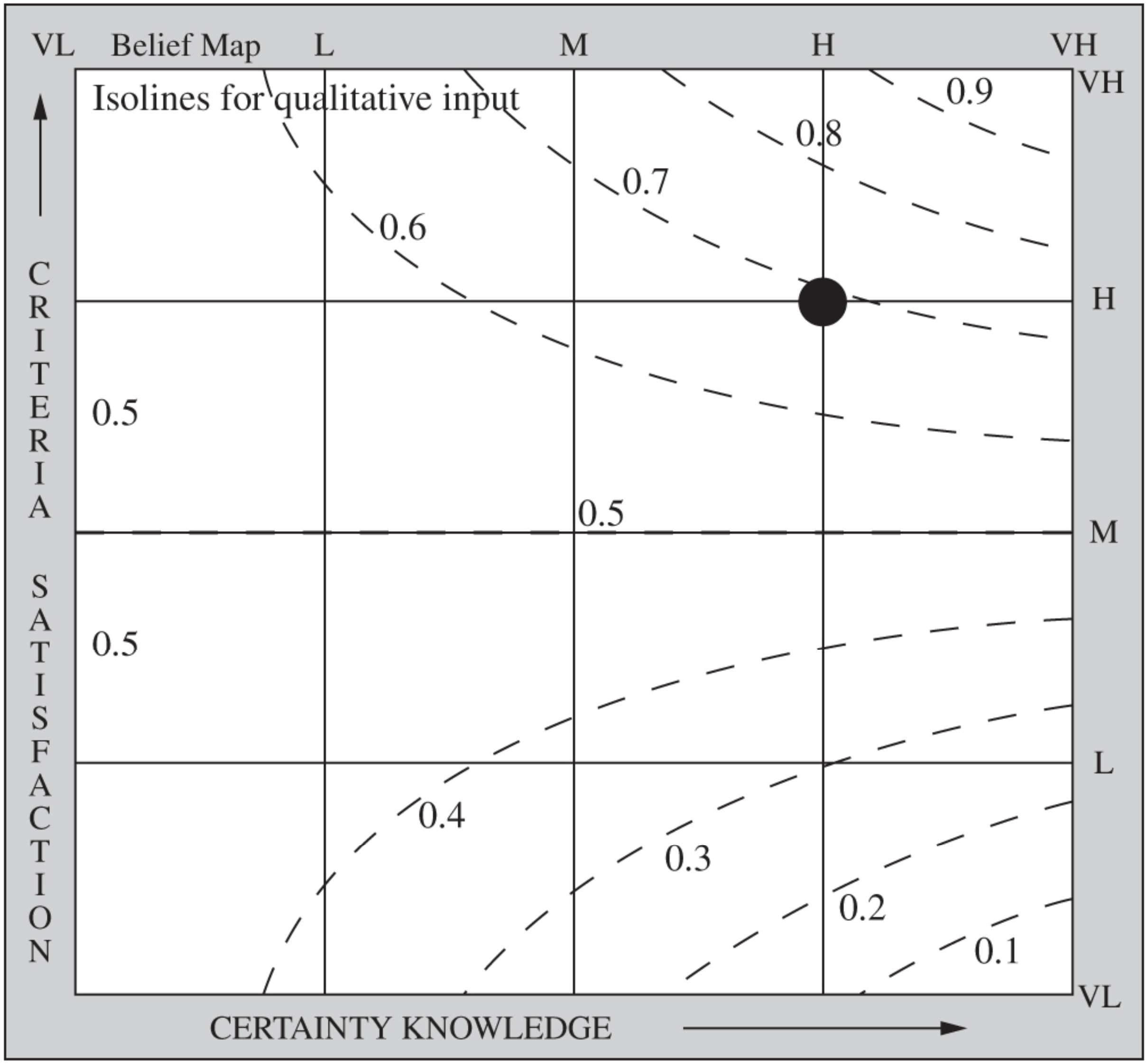
Table 8.5 The risk or mishap-assessment matrix

	Hazard category			
Frequency of occurrence	I Catastrophic	II Critical	III Marginal	IV Negligible
A. Frequent	1	3	7	13
B. Probable	2	5	9	16
C. Occasional	4	6	11	18
D. Remote	8	10	14	19
E. Improbable	12	15	17	20

Hazard-risk Index	Criterion
1–5	Unacceptable
6–9	Undesirable
10–17	Acceptable with review
18–20	Acceptable without review

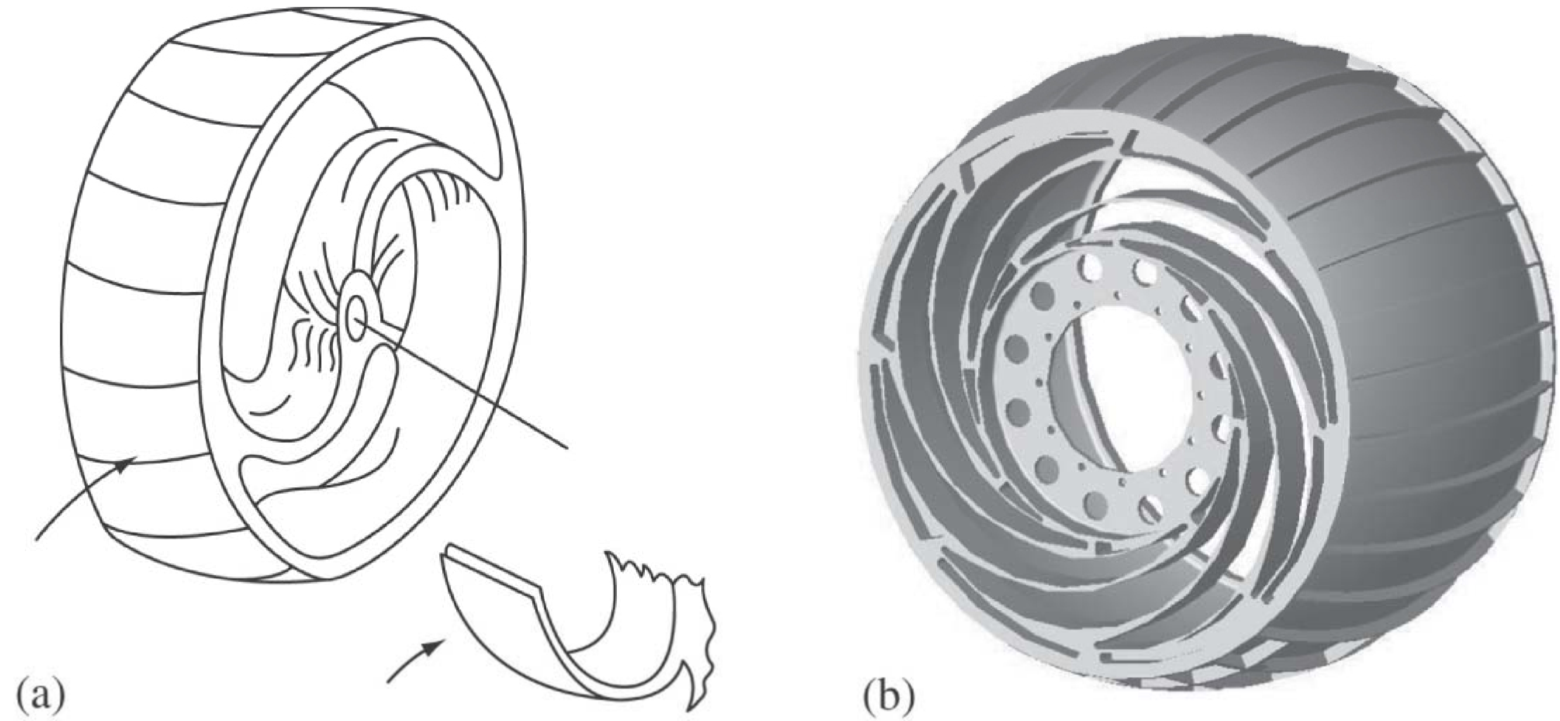
Source for Tables 8.3–8.5: MIL-STD 882E.

Figure 8.11



VL
Belief Map
L
M
H
VH
Isolines for qualitative input
0.9
0.8
0.7
0.6
0.5
0.5
0.5
0.4
0.3
0.2
0.1
VH
H
M
L
VL
CRITERIA SATISFACTION
CERTAINTY KNOWLEDGE

Figure 8.12



Belief map basics

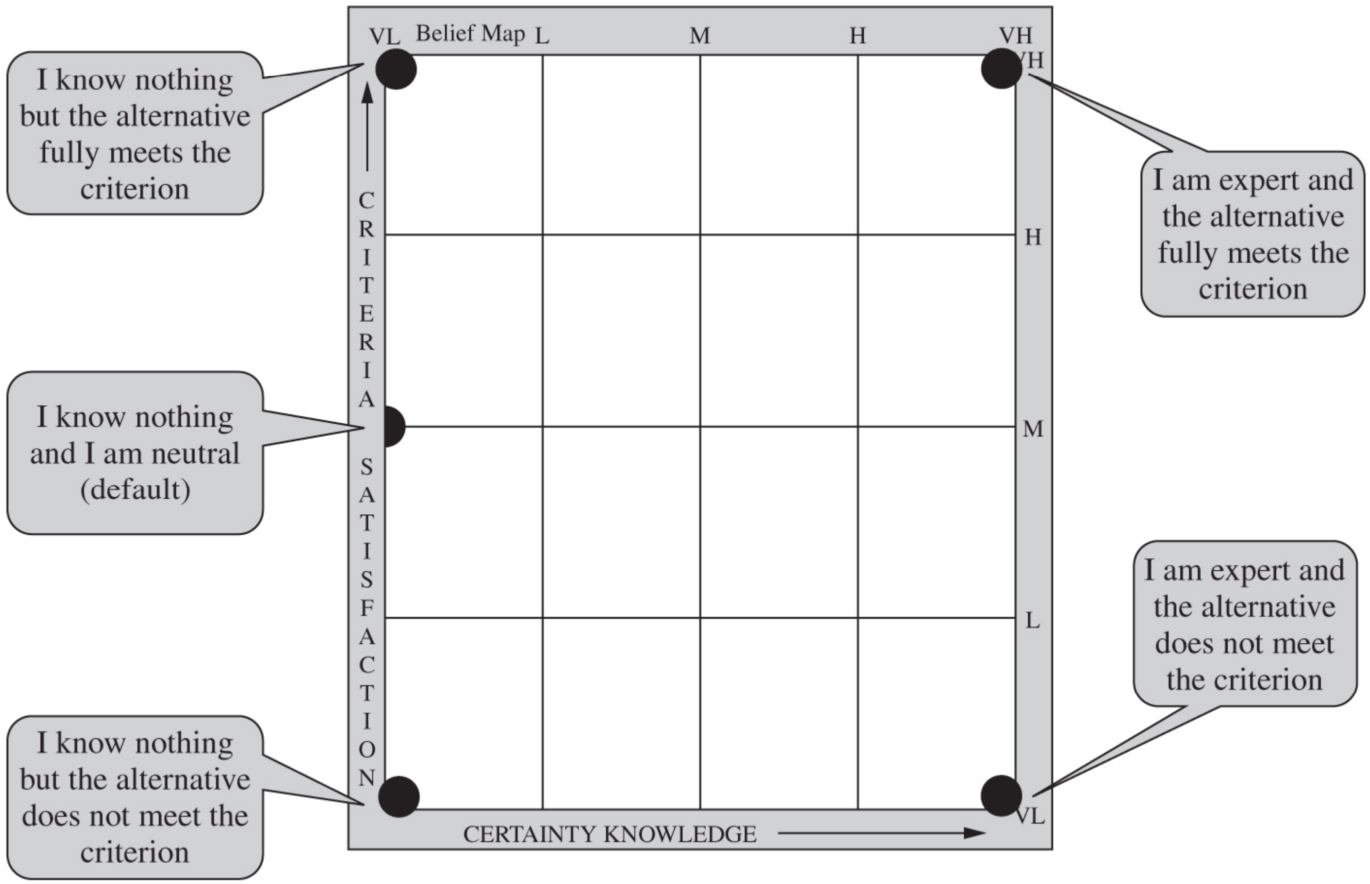


Figure 8.14

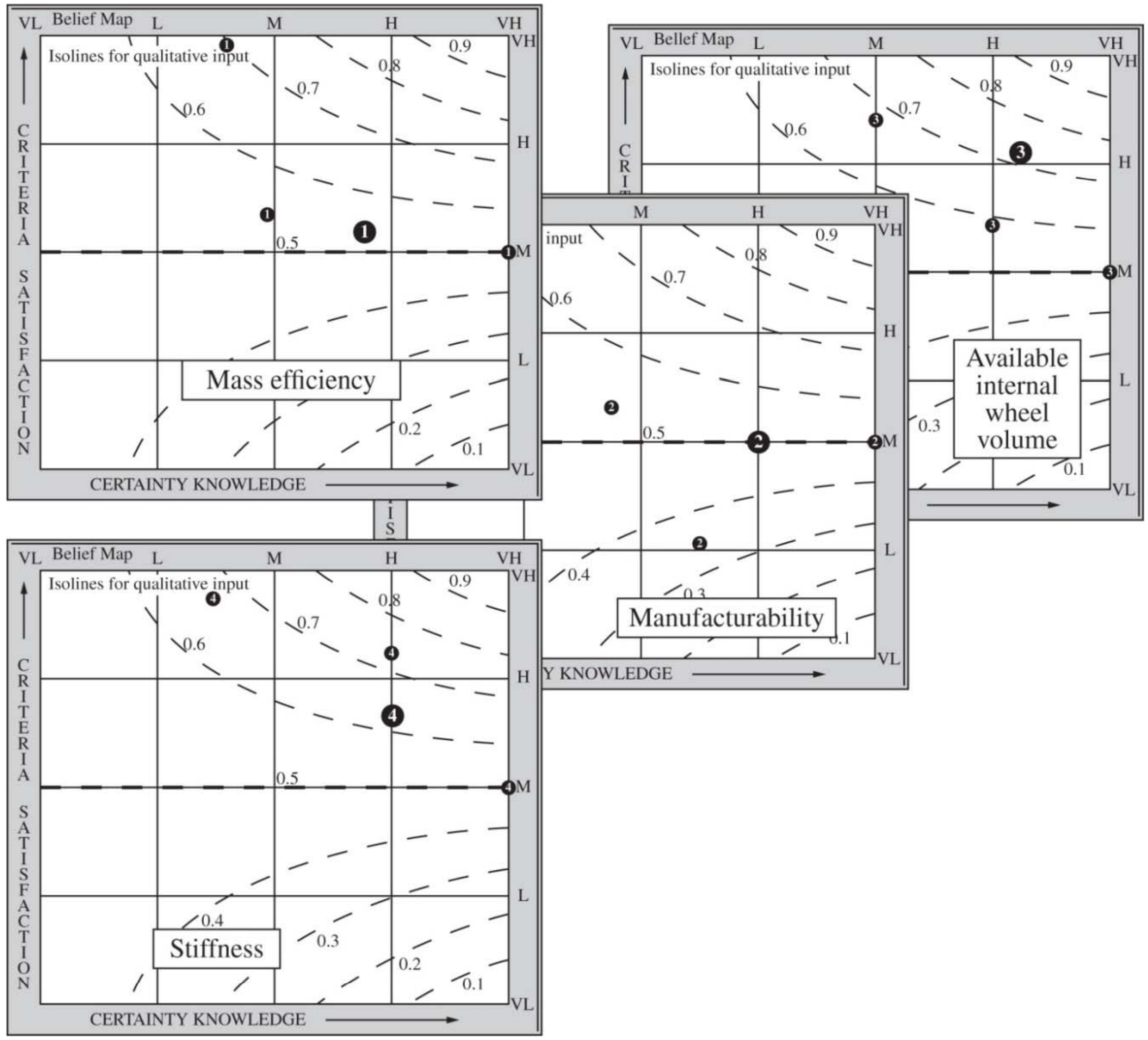

Belief Map
Isolines for qualitative input
CRITERIA SATISFACTION
CERTAINTY KNOWLEDGE
VL
L
M
H
VH
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Mass efficiency
Manufacturability
Available internal wheel volume
Stiffness

Figure 8.15

Issue: Choose a MER wheel configuration		Baseline	Cantilevered Beam	Hub Switchbacks	Spiral Flexures	Multipiece
Mass efficiency	35	0.5	0.55	0.55	0.77	0.71
Manufacturability	10	0.5	0.5	0.35	0.4	0.52
Available internal wheel volume	20	0.5	0.72	0.58	0.84	0.67
Stiffness	35	0.5	0.62	0.74	0.86	0.68
	Satisfaction	50	60	60	78	67